

# **Process Specification for Cleaning of Hardware**

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**Engineering Directorate**

**Structural Engineering Division**

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## Process Specification for Cleaning of Hardware

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REVISIONS		
REVISION	DESCRIPTION	DATE
--	Original version	5/96
A	PRC was reviewed and updated for accuracy. Author was changed.	8/5/99
B	Author change and replaced CFC-113 with HFE-7100 in Section 6.0	01/02/01
C	General changes due to reorganization (changed EM to ES, MMPTD to SED, Manufacturing, Materials, and Process Technology to Structural Engineering. PRC was updated and reviewed for accuracy.	2/20/04
D	Updated Organizational Changes and updated for accuracy.	1/30/06
E	Major Revision and updated for accuracy.	7/2/2008
F	PRC was revised to add new requirements and updated for accuracy	2/28/2011

## **1.0 SCOPE**

This process specification establishes surface cleanliness requirements for cleaning, handling, inspection and packaging of flight hardware and ground support equipment (GSE) at Johnson Space Center (JSC).

## **2.0 APPLICABILITY**

This process specification applies to general cleaning of flight hardware after fabrication (prior to assembly, after assembly, and/or prior to delivery). It does not apply to in-process cleaning during manufacturing (such as surface preparation for bonding or coating), other than the descaling of stainless steel parts.

## **3.0 USAGE**

Cleanliness level requirements for particulate and nonvolatile residue are defined in JPR 5322.1 "Contamination Control Requirements Manual". The responsible design or using organization selects cleanliness levels listed in Table I. GSE that interfaces with precision-cleaned flight fluid systems shall be cleaned to at least the cleanliness level of the flight hardware. Insufficient cleanliness of components used on oxygen systems may result in the ignition of contamination or components.

Cleanliness levels shall be specified as in the following examples:

- a. Level 200 refers to limits on particulate matter contamination only.
- b. Level 200B refers to limits on particulate matter and non-volatile residue (NVR) contamination.
- c. Level B refers to limits on NVR only
- d. Level 200 A is a more stringent cleaning level than 300B for both particulate matter and NVR.

**NOTE:** Contamination control in JSC flight hardware and components used in oxygen services is imperative to prevent hazards and component failure due to contamination.

This process specification shall be called out on the engineering drawing by using a drawing note that identifies the process specification to be used and the required level of cleanliness. For example:

**AFTER HEAT TREATING, REMOVE OXIDE TINT BY DESCALING PER NASA/JSC PRC-5001.**

**CLEAN ALL INTERNAL SURFACES TO LEVEL 300A PER NASA/JSC PRC-5001.**

#### **4.0 REFERENCES**

The following references were used to develop this process specification:

ES-007.1                      “Preparation and Revision of Process Specifications”

JPR 8500.4                      “Engineering Drawing System Manual”

The following documents are called out as an extension of the requirements given in this specification. All documents listed are assumed to be the current revision unless a specific revision is listed.

JPR 5322.1                      “Contamination Control Requirements Manual”

ASTM A380-94a                      “Standard Practice for Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment, and Systems”

The latest revision of the documents listed below is applicable to the extent specified herein.

**Refer any conflicts between the documents referred in this list to the Materials and Processes Branch.**

#### **4.1 FEDERAL STANDARDS AND SPECIFICATIONS**

- a. A-A-1689B “Tape, Pressure Sensitive Adhesive”
- b. TT-I-735A, "Specification, Isopropyl Alcohol"

#### **4.2 INTERNATIONAL ORGANIZATION FOR STANDARDIZATION**

- a. ISO-14644-1, “Clean rooms and Associated Controlled Environments Part 1 Classification of Air Cleanliness”

- b. ISO-14644-2, "Clean rooms and Associated Controlled Environments Part 2 Specifications for Testing and Monitoring to Prove Continued Compliance with ISO-14644-1"
- c. ISO14952-2 "Space Systems Surface Cleanliness of Fluid Systems Part 2 Cleanliness Levels

#### **4.3 ASTM STANDARDS AND PRACTICES**

- a. ASTM D2109-01, "Nonvolatile Matter in Halogenated Organic Solvents and Their Admixtures"
- b. ASTM F51-00, "Sizing and Counting Particulate Contaminant in and on Clean Room Garments"
- c. ASTM D1605, "Standard Recommended Practices for Sampling Atmospheres for Analysis of Gases and Vapors"
- d. ASTM F318, "Standard for Sampling Airborne Particulate Contamination in Clean Rooms for Handling Aerospace Fluids"
- e. ASTM E595-07, "Standard Test Method for Total Mass Loss and Collected Volatile Condensable Materials From Outgassing in a Vacuum Environment"
- f. ASTM F24, "Standard Method for Measuring and Counting Particulate Contamination on Surfaces"
- h. ASTM G144-01 "Standard Test for Determination of Residual Contamination of Materials and Components by Total Carbon Analysis Using a High Temperature Combustion Analyzer."

#### **4.4 INSTITUTE OF ENVIRONMENTAL SCIENCES AND TECHNOLOGY PUBLICATIONS**

- a. IEST Handbook of Recommended Practices, Contamination Control Division
- b. IEST-RP-CC-002.2, "Unidirectional Flow Clean Air Devices"
- d. IEST-STD-CC1246, "Product Cleanliness Levels and Contamination Control Program"

#### **4.5 MILITARY HANDBOOKS, SPECIFICATIONS, STANDARDS, AND TECHNICAL ORDERS (TOs)**

- a. MIL-A-18455, "Argon, Technical"
- b. MIL-C-10578, "Corrosion Removing and Metal Conditioning Compound (Phosphoric Acid Base)"
- c. MIL-STD-2073 "Procedures for Development and Application of Packaging Requirements"
- d. MIL-P-27401, "Propellant, Pressuring Agent, Nitrogen"
- e. MIL-HDBK-406, "Contamination Control Technology Cleaning Materials for Precision-Cleaning and Use in Clean Rooms and Clean Work Stations"

- f. MIL-HDBK-407, "Contamination Control Technology Precision-Cleaning Methods and Procedures for Precision Pre-Cleaning"
- g. TO 00-25-203, "Contamination Control of Aerospace Facilities, US Air Force"
- h. TO 42C-1-11, "Cleaning and Inspection Procedures for Ballistic Missile Systems"

#### **4.6 NASA PROCEDURES, REQUIREMENTS, SPECIFICATIONS, AND STANDARDS**

- a. JPR 8080.5 "JSC Design and Procedural Standards"
- b. KSC-C-123, "Specification for Surface Cleanliness of Fluid Systems"
- c. MSFC-PROC-166, "Procedures for Cleaning, Testing, and Handling Hydraulic System Detailed Parts, Components, Assemblies, and Hydraulic Fluids for Space Vehicles"
- d. MSFC-SPEC-164, "Specification for Cleanliness of Components for Use in Oxygen, Fuel, and Pneumatic Systems"
- e. MSFC-STD-246, "Standard Design and Operation Criteria of Controlled Environmental Areas"
- f. NASA-HDBK-6022, "NASA Standard Procedures for the Microbiological Examination of Space Hardware"
- g. NHB 5340.2, "NASA Standards for Clean Rooms and Work Stations for the Microbially Controlled Environment"
- h. NASA-STD-6001, "Flammability, Odor, Offgassing, and Compatibility Requirements and Test Procedures for Materials in Environments That Support Combustion"
- i. NSTS 07700, Volume XIV, "Space Shuttle System Payload Accommodations," section 3.6.12, "Contamination Control"
- j. NSTS 08242, "Limitations for Non-flight Materials and Equipment Used in and Around the Shuttle Orbiter Vehicles"
- k. SE-S-0073, "NSTS Specification, Fluid Procurement and Use"
- l. SN-C-0005, "Contamination Control Requirements for the Space Shuttle Program"
- m. SP-5015, "Advances in Sterilization and Decontamination, A Survey," 1978
- n. SP-5076, "Contamination Control Handbook," 1969
- o. CxP 70156 "Constellation Program Fluid Procurement and Use Control Specification"

#### **4.7 OTHER REFERENCES**

- a. SAE-ARP598, "Aerospace Microscopic Sizing and Counting of Particulate Contamination for Fluid Power Systems"
- b. ANSI Z9.2, "Fundamentals Governing the Design and Operation of Local Exhaust Systems"
- c. MDC H4070 (Space Station), "Contamination Control Plan"

- d. The Boeing Company MA0110-301, "Product Cleanliness"
- e. "Spacecraft Cleanliness Control for Particles," 10th International Symposium on Contamination Control (ICCCS 90), Zurich, Switzerland, September 10-14, 1990

## 5.0 **REQUIREMENTS**

All parts, components, assemblies, systems or related equipment requiring cleaning must be cleaned to the specified cleanliness level and inspected in accordance with this specification. Assemblies and systems may require disassembly to permit cleaning. Remove any part or component that might degrade during cleaning and clean as a separate item. Only trained and certified personnel must perform cleaning and disassembly operations on precision cleaned parts.

**NOTE:** It is the responsibility of the users of this specification to review pertinent Materials Safety Data Sheets (MSDSs) and materials specification to assure safety of the personnel, protection of the environment and facilities in fulfilling the requirements of this document.

### 5.1 **CLEANING**

All significant surfaces of the hardware must be pre-cleaned to remove dirt, grit, scale, corrosion, grease, oil and other foreign matter prior to any final precision cleaning process. Metallic parts shall be surface treated (cleaned, passivated, pickled and/or coated) as necessary to prevent latent corrosion and contamination.

Assembled items that do not lend themselves to this type of treatment must be treated prior to assembly. Surface treated areas degraded during subsequent fabrication and assembly shall be reprocessed as required to restore the original protective finish.

Significant surfaces of pre-cleaned system hardware must be visibly clean prior to precision cleaning. The precision cleaning levels are specified JPR 5322.1 Table I. Precision cleaning operation must be performed in an environmentally controlled area that meets the cleanliness requirements of the parts to preclude adverse effects the performance of the parts per JPR 5322.1. Precision cleaned hardware must be packaged per JPR 5322.1 Table V prior to leaving the controlled environment.

**Table I. Classification of Cleanliness Levels Requirements**

A. Particulate Matter Contamination Levels			B. NVR Contamination Levels		C. Visible Contamination Levels	
Level	Particle Size Range (micrometer)	Maximum Number of Particles per 0.1 m <sup>2</sup> *	Level	Maximum Quantity of NVR (mg per 0.1m <sup>2</sup> )	Level	Definition
25	<5	Unlimited	A	1	GC	<b>Generally Clean.</b> Freedom from manufacturing residue, dirt, oil, grease, etc. The GC level should therefore be specified for hardware that is not sensitive to contamination and is easily cleaned or recleaned.
	5 to 15	19				
	>15 to 25	14				
	>25	0				
50	<15	Unlimited	B	2		
	15 to 25	17				
	>25 to 50	8				
	>50	0				
100	<25	Unlimited	C	3		
	25 to 50	68				
	>50 to 100	11				
	>100	0				
150	<50	Unlimited	D	4	VC	<b>Visibly Clean.</b> Free all particulate and nonparticulate matter visible to the normal unaided eye or corrected vision eye. This level is for hardware that requires removal of surface particulate and nonparticulate for operation; or hardware for which recleaning would be difficult and/or time-consuming.
	50 to 100	47				
	>100 to 150	5				
	>150	0				
200	<50	Unlimited	E	5		
	50 to 100	154				
	>100 to 200	16				
	>200	0				
250	<100	Unlimited	F	7		
	100 to 200	39				
	>200 to 250	3				
	>250	0				
300	<100	Unlimited	G	10		
	100 to 250	93				
	>250 to 300	3				
	>300	0				
500	<100	Unlimited	H	15	VC+UV	<b>Visibly Clean + Ultraviolet.</b> Visually clean and inspected with ultraviolet light. This level is usually specified for hardware that cannot tolerate buildup of hydrocarbons between uses or operations.
	100 to 250	1073				
	>250 to 500	27				
	>500	0				
750	<250	Unlimited	J	25		
	250 to 500	205				
	>500 to 750	9				
	>750	0				
1000	<500	Unlimited				
	500 to 750	34				
	>750 to 1000	5				
	>1000	0				
*No silting permitted						



## 5.2 CLEANING FLUID REQUIREMENTS

It is the cleaning contractor's responsibility to ensure that the cleaning solution or cleaning process is compatible with any material or part used in that solution or process.

The cleaning fluid(s) and cleaning procedure(s) used in a cleaning method must be capable of assisting to clean the component, product, etc., to the required cleanliness level. The cleaning methods and procedures must be well understood. Additionally, the cleaning fluid should be:

- a. Nontoxic (not harmful if inhaled or spilled on the skin) and nonpoisonous.
- b. Non-explosive.
- c. Noncorrosive under normal use.
- d. Nonflammable.

**NOTE:** (i) This does not limit potential cleaning fluids only to nonflammable fluids. Flammable cleaning agents, such as isopropanol, shall not be used when cleaning oxygen systems or equipment that may combust flammable materials.

(ii) In general, combustible cleaning agents must be used with care to clean systems or products that may combust the cleaning agent during cleaning; or even at a later time such as when the system or product is packaged, stored, used, etc.

(iii) The cleaning contractor must verify complete solvent removal after final cleaning.

e. Environmentally sound.

f. Compatible with the system, product materials and hardware being cleaned. Specifically, the cleaning fluid must not react with, combine with, etch, or otherwise cause immediate or later degradation.

## 5.3 NEW PROCESS APPROVAL

For the introduction of new materials into pre-clean solvents or the development of new processes that are not documented by existing detailed process instructions (DPI), the Materials and Processes Branch must be consulted regarding materials, cleaning processes and compatibility concerns. Materials or sample parts that duplicate those to be used in the new process must be tested to demonstrate compatibility and to qualify the process. To obtain approval, the contractor must submit documentation (e.g. JF881, JF1225C) with all of the following information:

- a. Proposed cleanliness levels including analysis and rationale for the selected cleanliness level.

- b. Descriptions of items to be cleaned including identification of materials including trade names, specifications, chemical and physical properties and compatibility information.
- c. Cleaning fluids information to include as applicable, trade names, specifications, chemical and physical properties, and compatibility information.
- d. Processing equipment and cleaning procedures to be used (e.g. ultrasonic equipment, precision cleaning).
- e. Quality assurance provisions. This must include inspection(s) and in-process control procedures to prevent contamination, latent corrosion, or other degradation of surfaces and opened systems.
- f. Controlled environment levels to be maintained for cleaning and handling.
- g. Preservation methods and materials.
- h. Verification methods.

Compatibility issues that must be considered and evaluated before selecting a cleaning process are:

- a. Corrosion
- b. Embrittlement
- c. Leaching
- d. Residue
- e. Crazeing (non-metallics)
- f. Reversion (non-metallics)
- g. Hydrolysis (non-metallics)

## **6.0 SURFACE CLEANLINESS LEVELS**

Surface cleanliness levels are defined in Section 4.0 in JPR 5322.1 "Contamination Control Manual".

**NOTE:** For ISS hardware, the ISS program requires a cleanliness level of VC sensitive per SN-C-0005, as-specified in SSP 30426 "Space Station External Contamination Control Requirements" for external hardware and in SSP 41000 "ISS System Specification" for internal hardware.

## **6.1 PRECISION CLEANLINESS LEVELS**

The responsible design or use organization shall specify the level of cleanliness according to the cleanliness levels found in Table I. Personnel trained in accordance with Section 9.0 of this manual shall perform sampling and certification tasks to attain specified cleanliness levels.

## **7.0 CLEANING REQUIREMENTS**

The intent of this section is to specify those general requirements applicable to cleaning processes. Pre-cleaning must be done prior to final or precision cleaning.

Since the characteristics of the assemblies or components being cleaned vary, this section does not describe all cleaning methods and processes. The cleaning methods selected and used depend on which materials the parts to be cleaned are fabricated from. Details of which solvents to use for which materials can be found in DPI-5001-04 for pre-cleaning and DPI-5001-07 for precision cleaning. However, some information about nonmetallic pre-cleaning methods is covered separately in Section 7.4.3, since these cleaning methods vary markedly from those used for metallic components.

### **7.1 PROCUREMENT**

The cleaning contractor shall adhere to the applicable contamination control requirements of this specification and JPR 5322.1 "Contamination Control Manual."

### **7.2 ENVIRONMENTALLY CONTROLLED AREAS**

Precision cleaning, assembly, processing and functional testing of the hardware shall be conducted in facilities which provide airborne contamination levels compatible with the hardware cleanliness requirements per JPR 5322.1 "Contamination Control Manual." Clean rooms and other environmentally controlled areas (ECAs) shall be controlled by approved documented procedures.

The cleaning contractor must establish and implement the requirements for the periodic certifications of the clean room, clean workstations, or other environmentally controlled areas. This certification process shall be controlled by established and documented procedures. The Safety and Mission Assurance Directorate has the approval authority for the certification.

### **7.3 CLEANING FLUIDS AND SOLUTION CONTROL**

#### **7.3.1 *Cleaning Fluids***

For all cleaning fluids, establish, document, and implement requirements and procedures that control fluid composition, purity, cleanliness, and use. Cleaning fluids selected for use in pre-cleaning solutions shall be controlled by analysis, solution replacement, or

adjustment to maintain cleaning effectiveness and compatibility with the specific type of material being cleaned.

### 7.3.2 *Solution Control Records*

The cleaning contractor must maintain records indicating the scheduled analysis, analysis results, and any solution replacement or adjustment activities.

All fluids, equipment, and facilities used for cleaning to the VC or VC + UV cleanliness levels shall be subject to the same minimum requirements specified for pre-cleaning procedures. Cleaning with an approved, compatible solvent (e.g., solvent wipe) is mandatory for VC and VC + UV items, unless other methods are required by the hardware in question. GC items do not require cleaning before inspection; cleaning is required only if the item does not pass GC inspection. Use a GC cleaning process compatible with the hardware materials.

### 7.3.3 *Aqueous Based Fluids*

- a. Aqueous based fluids must utilize reagent grade water. The reagent water must meet the requirements of ASTM D1193, Type II except that silica content is not required. Milli-Q water may be substituted for reagent water.
- b. For passivation and picking baths, control chemistry per PRC-5002.

### 7.3.4 *Final Rinsing Solvent*

Analyze final flush and verification fluids for precision cleanliness for NVR prior to use to determine compliance with the stipulated specification requirements.

- a. Nonvolatile residue for HFE-7100 shall not be greater than 10 milligrams per one liter (mg/L) as determined by SE-S-0073.
- b. If water is the final rinse fluid it must meet the requirements as specified in SE-S-0073 Grade B.
- c. Isopropanol must meet the requirements of TT-I-735A filtered to 10 microns or better prior to use.

### 7.3.5 *Special Cleaning Processes*

Control special cleaning processes, such as ultrasonic cleaning and surge cleaning, by documented procedures.

- 7.3.5.1 Ultrasonic Cleaning. Test ultrasonic cleaning equipment to verify that adequate cavitation turbulence for good cleaning action is maintained. Conduct such tests using the manufacturer's recommended test method.

- 7.3.5.2 Ultrasonic Fluid. The fluid used in ultrasonic cleaning equipment should be as recommended by the manufacturer. However, if an alternative fluid is used, perform tests to verify that the alternative fluid does, indeed, perform the proper cleaning action and is compatible with articles to be cleaned.
- 7.3.5.3 Surge Cleaning. Use a specific pressure or flow controls to prevent damage to the item from pressure or vacuum cleaning. Do not clean items such as pressure vessels, which are sensitive to pressure cycle fatigue, using a surge cleaning procedure.

## 7.4 PRE-CLEANING HARDWARE

Pre-clean (rough clean) each item requiring precision cleaning to the VC level before placing it in a clean room or clean workstation. Pre-cleaning shall be controlled by detailed process instructions (DPI) that have been approved by the NASA JSC Materials and Processes Branch. Nonmetallic materials shall be pre-cleaned with soap and water.

### 7.4.1 *Pre-cleaning Process Controls*

Parts must be pre-cleaned to remove all visible contaminants without removing or changing the characteristics of the base materials. All traces of pre-cleaning materials shall be removed from parts at the completion of the pre-cleaning process to prevent the future formation of mineral salts and corrosion products. Use tests, such as pH testing, to verify removal of all residuals.

### 7.4.2 *Work Flow*

All steps in pre-cleaning procedures must progress in an uninterrupted workflow through the final rinse and drying operation. If the workflow is unavoidably interrupted, a recycling operation shall be specified in the pre-cleaning procedure. Pre-cleaning procedures shall include, as a minimum, protection of the item by interim packaging or other approved means to prevent recontamination through all subsequent operations.

### 7.4.3 *Non-Metallic Cleaning and Rinse Test*

For the purpose of this document, nonmetallic materials include natural rubber, Teflon<sup>®</sup>, nylon, Kel-F<sup>®</sup>, polytetrafluoroethylene, polyethylene, polycarbonates, and other plastic or synthetic rubber materials. The cleaning solution and method must not adversely affect the materials including external damage, swelling, silting, absorb the cleaning solution, and/or cause outgassing. High purity water must be used for precision cleaning and verification. With the exception of Teflon<sup>®</sup> lined flex hoses, HFE-7100 may also be used for precision cleaning and verification.

## 7.5 INSPECTION

Accomplish non-UV visual inspection under a white light of sufficient intensity to adequately illuminate the surface being inspected. Inspections shall be performed as follows:

### 7.5.1 Visual Inspection

VC and VC + UV levels. Items must be inspected to the VC level A visual inspection must be performed with the unaided eye (corrective lenses are acceptable) under a white light of sufficient intensity to illuminate the surface being inspected. Borescopes, mirrors, or other devices may be used to increase accessibility during inspection. Magnifying lenses may be used only to further identify visible contaminants

Where configuration, color, or other item characteristics interfere with visual observation, the following method shall be used to augment visual inspections.

- 7.5.1.1 Wipe Test. The surface to be inspected shall be wiped with a lint-free, item-safe, and fluid-safe medium. The medium shall be observed for the presence of contaminants. Care shall be taken when wiping parts, especially since soft metals; e.g., aluminum can abrade and soil the medium, giving an erroneous indication of contamination. The wiping medium shall be subjected to the blacklight inspection specified in section 7.5.2.

**NOTE:** When the wiping medium is subjected to further tests, such as blacklight or hydrocarbon evaluation, a baseline reading of the blank medium must be determined and accounted for in subsequent evaluations.

- 7.5.1.2 Water Break Test. The surface to be inspected shall be placed in the horizontal, face-upward position. Distilled purified water from an atomizer shall be used to spray the surface to completely cover the area of interest. The presence of droplets or breaks in the water film will be an indication of possible oily hydrocarbons.

### 7.5.2 Blacklight (UV) Inspection

A visual observation of the part must be performed with the unaided eye (corrective lenses are acceptable) under UV light (3,200 to 3,800 angstroms wavelength) for the presence of hydrocarbons. If the surface to be inspected is inaccessible, a wipe test shall be performed and the wiping medium inspected under UV light.

**NOTE:** Any contamination detected by visual or black light inspection shall be cause for re-cleaning. If re-cleaning fails to remove fluorescent indications, investigate to determine if the item material is naturally fluorescent. Parts shall be inspected as specified in JPR 5322.1. For the GC Level, locations with cracks, crevices, holes, etc., which may trap or retain contamination, must receive particular attention.

### 7.5.3 VC Standard, Sensitive, Highly Sensitive Levels.

Refer to Table A.2 of SN-C-0005 "Space Shuttle Contamination Control Requirements"

**NOTE:** (1) JPR 5322.1 does not define the VC Standard, Sensitive or Highly Sensitive levels; specify the minimum illumination levels, or viewing distances. The hardware acceptance criteria are essentially the same as in SN-C-0005.

(2) The viewing distance specified in SN-C-0005 is a result of its heritage as a document for cleaning large surface areas such as the Orbiter Payload Bay. Flight hardware at JSC is inspected at component level and at a significantly closer distance typically one foot.

Per JPR 5322.1, visibly clean hardware must be cleaned prior to inspection and generally clean hardware does not require cleaning unless it fails inspection. Because the inspection requirements are much closer than those specified in SN-C-0005, the lighting for the inspection process is adequate for all hardware verified to the JPR 5322.1 generally clean (GC) or visibly clean (VC) level. This complies with the ISS requirements for visibly clean sensitive per SN-C-0005.

## **7.6 PRECISION-CLEANING PROCESS CONTROLS**

Hardware shall be precision-cleaned in a clean room environment, following pre-cleaning operations described herein. Flush or wipe the items to be precision-cleaned with a suitable cleaning solution or solvent and/or vacuum clean or blow off with clean dry air to prevent the entry of gross contaminants into the clean room environment. Hardware must be precision cleaned using a precision-cleaning agent.

Work instructions that control the precision-cleaning processes shall be developed by the cleaning organization and approved by the NASA JSC Materials and Processes Branch. At JSC, these work instructions are called Detailed Process Instructions (DPIs).

### *7.6.1 Cleanliness Verification*

Following precision cleaning, each item shall be rinsed with an appropriate amount of unused precision-cleaning solvent usually (100 mL) for each square foot of critical surface. Determine non-volatile residue (NVR) in accordance with ASTM D2109-01. If high purity water is used as the final rinse solution for verification, hydrocarbon content shall be determined using total organic carbon (TOC) analyzing techniques per ASTM G144-01.

Particulate determination shall be made in accordance with the requirements of SAE-ARP598.

### *7.6.2 GSE Interface Filtering*

For ISS hardware, GSE that interfaces with precision cleaned flight fluid systems must incorporate filters as established and controlled by SSP 30573 and located as close to the interface as possible where flow could occur in to the flight hardware. This may also include outlet lines if it is determined that some operations such as servicing and desubliming fluids could permit flow in a reverse direction.

## 7.7 HANDLING

Refer to JSC 29253 “SR&QA Recommendation for Clean Room Gloves” for gloves for wet and dry handling of hardware. Handle items cleaned to the VC + UV, VC, and GC levels as follows:

- a. VC + UV level. Handle items cleaned to the VC + UV level the same as precision-cleaned items (i.e., with approved gloves, forceps, or tweezers).
- b. VC level. Handle items cleaned to the VC level with approved gloves if so specified by the responsible design or using organization.
- c. GC level. Gloves are not required for the handling of GC items.

**NOTE:** For ISS, all hardware that has not been precision cleaned shall not be brought into the vicinity of precision cleaned hardware without the protecting the precision cleaned hardware

## 7.8 DRYING

Components must be thoroughly dried to remove residual cleaning, rinsing, and/or verification media. Use nitrogen gas dry (A-A-59503, Type I). When purging is specified, the purging material shall be a pre-cleaned, dry, inert gas (e.g., argon), conforming to MIL-A-18455; or nitrogen conforming to A-A-59503, Grade A, or equivalent. Pre-filter gases to meet the cleanliness level of the item being precision packaged.

**NOTE:** It is the cleaning contractor's responsibility to ensure removal of the above substances prior to packaging or placing hardware into service.

## 7.9 FINAL PACKAGING

Package all cleaned and precision-cleaned items immediately after cleaning and drying in accordance to packing methods per JPR 5322.1 “Contamination Control Manual.”

Prepackage electrical and electronic items that will require testing upon arrival at destination and during storage in a manner that will permit access to the leads, pigtails, etc., without degrading the integrity of the unit package.

**NOTE:** Exercise caution when processing electrical or electronic hardware that is sensitive to electrostatic discharge (ESD) damage. Special materials and techniques may be necessary to control ESD. Use materials for contamination and ESD control only if approved by the Occupational Safety and Quality Assurance Branch. Contamination control packaging shall not be placed inside ESD control packaging.



## 7.10 CERTIFICATION DECALS

Identify the bagged item with a decal containing identification, inspection, and certification of cleanliness information. Decals procured to meet the requirements of this section are not intended for direct application to parts or equipment; therefore, the decals need not be compatible with fuels or oxidizers. Apply decals to the outside of the inner bag and over the ends of tape-sealed closures.

**NOTE:** To prevent galvanic corrosion, do not place metals dissimilar to the item in contact with the item. Refer to MIL-STD-889.

Do not use preservative materials on items, which have been precision-cleaned.

## 8.0 STORAGE OF CLEANED ITEMS

Remove completely cleaned and precision-cleaned and packaged items from the clean room and place in an appropriate container or storage area to protect the plastic bags and contents.

### 8.1 IDENTIFICATION AND CERTIFICATION

Cleaned items must be identified with the appropriate certification tags and contain as a minimum the following information:

- a. Part or identification number
- b. Date of Cleaning
- c. Title, date and number of this standard or JPR 5322.1
- d. Service medium or intended use of component
- e. Acceptance stamps
- f. Cleanliness Level

**NOTE:** The GC level does not require a cleanliness certification decal, since protective packaging for contamination control is not required.

### 8.2 ENVIRONMENTAL CONTROL

Store all cleaned and precision-cleaned items in an enclosed, controlled area where temperature and humidity are maintained within limits compatible with the item and its packaging material. Filter the air supply through an industrial-grade filter. Maintain the enclosed area in a manner consistent with good housekeeping practices. Establish and document periodic cleaning schedules.

### 8.3 INSPECTION

Inspect stored precision-cleaned items periodically, at least once every two (2) years for the integrity of the outer bag and, on a sample basis, for corrosion or other degradation of the packaged item. To inspect, remove the outer bag and visually inspect the item through the inner wrap. Any discoloration, visible contamination, etc., shall be cause for rejection and re-cleaning of the lot sampled. If no cause for rejection is found, apply a new outer bag and reseal in the normal manner.

### 8.4 ACCESS CONTROLS

Establish adequate controls and procedures to limit access to storage areas for precision-cleaned items to personnel specifically trained in the handling of precision-cleaned items. At JSC, all hardware is treated as flight hardware.

## 9.0 PERSONNEL TRAINING

This section defines the minimum training requirements for operational, technical, and management personnel. The cleaning organization must train all personnel training in ECA operations as required and shall be accomplished by the successful completion of a formal training program per JPR 5322.1. In addition to ECA disciplines, personnel need only be trained and qualified in the operations that encompass their particular job responsibilities.

A certification training course shall be established and required for personnel working with precision-cleaned hardware for the ISS program regardless of work site according to ISS-PI-002 Maintenance of Fluid Systems Cleanliness.

Retraining of all personnel must be performed as required. Training records and certifications must be kept with traceable documentation.

**NOTE:** Personnel requiring entry to the ECA on a visit or on a temporary basis must be knowledgeable in the basic ECA disciplines or shall be instructed before entering. An escort qualified for ECA entry must escort and be directly responsible for such personnel. The appropriate ECA supervisor controls entry of visitors or temporary personnel to prevent overpopulation and compromise of ECA integrity.

## 10.0 **DEFINITIONS**

Cleanliness Level	(1) An established maximum of allowable contaminants based on size, distribution, or quantity on a given area or in a specific volume or (2) absence of particulate and nonparticulate matter visible under white light and/or UV illumination
Contaminant	Any unwanted matter that could be detrimental to the required operation, reliability, or performance of a part, component, subsystem, or system
Environmentally Controlled Area	A classification which includes clean rooms, laminar flow clean work stations, and CWAs
Generally Clean (GC)	Free of manufacturing residue, dirt, oil, grease, processing debris or other extraneous contamination. This level is achieved by washing, wiping, blowing, vacuuming, brushing or rinsing
Micron	A unit of measurement equal to one-millionth of a meter or approximately 0.00003937 in. (e.g., 25 microns are approximately 0.001 in.)
Nonparticulate Matter	Matter (usually film) with no definite dimension
Nonvolatile Residue (NVR)	Soluble (or suspended) material and insoluble particulate matter remaining after controlled evaporation of a filtered volatile solvent usually measured in milligrams. Filtration is normally through a 0.45-micrometer or 0.8-micrometer membrane filter before evaporation
Particulate Matter	The general term applied to matter with observable length, width, and thickness (as contrasted to nonparticulate film matter without definite dimensions)
Precision-cleaning	Final or fine cleaning accomplished in a controlled environment to achieve precision cleanliness. Surface cleaning with an approved, compatible solvent (e.g., solvent wipe) is satisfactory for VC + UV and VC items

Precision Cleanliness	A degree of cleanliness which requires special equipment and techniques for determination; precision cleanliness levels normally include limits for particulate sizes and quantities
Precision-Clean Packaging	Packaging or protection used to preserve precision cleanliness for a specific period and condition
Purge	To flow a gas through a system (or pipeline, tube, tank, etc.) for the purpose of removing residual fluid or for providing a positive flow of gas from some opening in the system
Silting	Accumulation of minute particles in the size range normally not counted with the respective service medium
Total Organic Carbon (TOC)	Amount of carbon molecules in a sampling fluid, typically water, as measured by controlled combustion. TOC is reported in parts per million (ppm) by weight as carbon
Visibly Clean (VC)	Free of all particulate and nonparticulate matter visible to the unaided eye (corrective lenses are acceptable)
Visibly Clean + Ultraviolet (VC + UV)	Visibly clean (as defined above) and without fluorescent matter detectable with a UV light (black light) of 3,200 to 3,800 angstroms wavelength
Visual Cleanliness Levels	A category which includes VC, VC + UV, and GC cleanliness levels